UNIT - III

Name :- Prof Anand Gharu
college :- PVGCOE, Nasik
Class :- TE COMPUTER
Subject :- TOC
8087777708

Context Free Grammars & Language

* Context Free Grammar (CFG) :- (Regular Grammar)

"A context free Grammar G is a quadruple (V, T, P, S)
where, V is set of variables
T is set of terminals.
P is set of productions
S is a special variable called start symbol $S \in V$.

A production is of the form
$V_i \rightarrow \alpha_i$ where $V_i \in V$ and α_i is string of terminal and variables.

Notations :-

1. terminal are denoted by lower case letters a, b, c or digits 0, 1, 2 --- 9
2. Non-terminal (variables) are denoted by capital letter A, B, C --- Z.
3. A string of terminals or a word $w \in L$ is represented using u, v, w, x, y, z.
4. Sentential form is a string of terminals and variables and it is denoted by α, β, γ etc.

e.g. Anand writes, Anand reads, Sunny watch

A sentense for above word can be written as

<sentense> $\rightarrow$ <noun> <verb>

Noun $\rightarrow$ Anand | Sunny

Verb $\rightarrow$ writes | reads | watch.

P = { sentense $\rightarrow$ noun | verb,
noun $\rightarrow$ Anand | sunny
verb $\rightarrow$ writes | reads | watch
}.

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* Sentential form :-

In sentential form, derivation starts from the start symbol through finite application of productions.

A string α is derived so far consist of terminals and non-terminals.

$$S \xrightarrow[G]{*} \alpha \mid \alpha \in (V \cup T)^*$$

- A final string consist of terminals.
- In left sentential form, leftmost symbol is picked up for expansion.
- In right sentential form, rightmost symbol is picked up for expansion.
- A string can be derived in two ways.
  1) Leftmost Derivation
  2) Rightmost Derivation.

e.g.

$S \rightarrow A1B$

$A \rightarrow 0A \mid \epsilon$

$B \rightarrow 0B \mid 1B \mid \epsilon$

where G is given by (V, T, P, S)

with

$V = \{S, A, B\}$

$T = \{0, 1\}$

$P = \{$ production $S \rightarrow A1B$, $A \rightarrow 0A \mid \epsilon$, $B \rightarrow 0B \mid 1B \mid \epsilon$ $\}$

S = start symbol.

" A language of grammar can be defined by creating the production rules for the given condition.

The language generated by context free grammar is called as Context free Language (CFL)

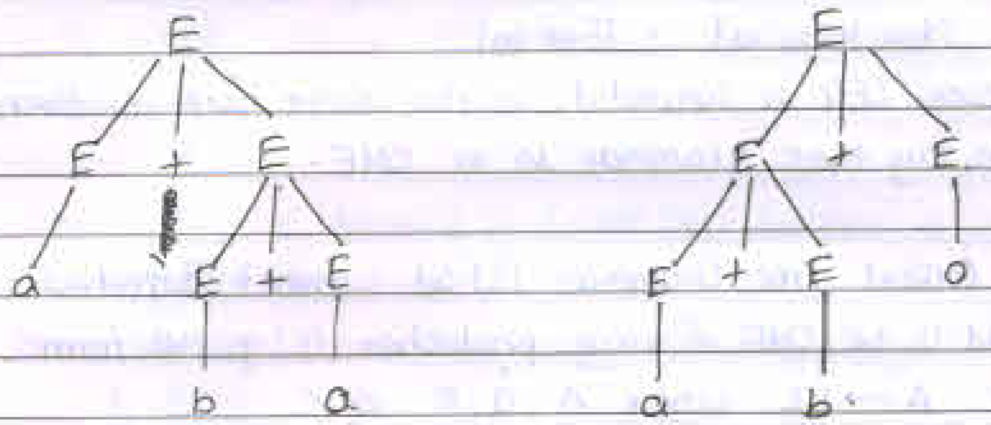
* Ambiguous Grammar :

"A grammar is said to be ambiguous if the language generated by grammar contains some string that has two different parse tree".

e.g.

$E \rightarrow E+E \mid a \mid b$;

A string a+b+a is generated by given grammar



Parse tree 1   Parse tree

As above, two parse tree are generated for string a+b+a so that's why it is ambiguous grammar.

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PVGCOE NASHIK
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* Elimination of Useless Symbol & Production

A grammar may contain symbols & productions which are not useful for derivation of string.

Two types of symbol are useless

1. Non-generating symbols
2. Non-reachable symbols.

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* Normal form :

There are 2 imp normal form

1] Chomsky's Normal form
2] Greiback Normal form

1] Chomsky's Normal form (CNF) :

→ The CNF can be defined as

Non-terminal → Non-terminal · Non terminal.
Non-terminal → Terminal

The given CFG is converted in the above format then we can say that grammar is in CNF.

" A Context Free Grammar (CFG) without ϵ-production is said to be CNF if every production is of the form

1. $A \rightarrow BC$ where $A, B, C \in V$
2. $A \rightarrow a$ where $A \in V$ and $a \in T$.

The grammar should have no useless symbols.
Every CFG without ϵ Productions can be converted into an equivalent CNF form. "

* Algorithm for CFG to CNF.

→ 1) Eliminate ϵ-production, unit Production & useless Symbol from grammar.

2) Every variable deriving a string of length 2 or more should consist only of variable.

$A \rightarrow \alpha$ with $|\alpha|$ should consist on variable.

e.g. $A \rightarrow V_1 V_2 a V_3 b V_4$

as $A \rightarrow V_1 V_2 C_a V_3 C_b V_4$ and adding two prod :

$C_a \rightarrow a$, $C_b = C_b$

3) Every produ, deriving of 3 or more variables ($A \rightarrow \alpha$ with $|\alpha| \geq 3$ can be split into cascade Production with each deriving a string of two variables.

e.g $A \rightarrow X_1 X_2 X_3 \ldots X_n$ where $n \geq 3$ with $|\alpha| \geq 3$

e.g Consider production $A \rightarrow X_1 X_2 \ldots X_n$ where $n \geq 3$ and X_i are variable.

$A \rightarrow X_1 C_1$
$C_1 \rightarrow X_2 C_2$
$C_2 \rightarrow X_3 C_3$

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* Greibach Normal Form (GNF)

→ "A context free Gramar $G = (V, T, P, S)$ is said to be in GNF if every production is of the form:

$$A \rightarrow a\alpha$$

where; $a \in T$ is a terminal &

α is string of zero or more variable

- The language $L(G)$ should be without ϵ
- RHS of each Prod should start with a terminal followed by a string.

- Removing Left Recursion :-

→ Elimination of left Recursion is a important step in algo. used in conversion of a CFG into GNF form

- Left Recursive grammar:

A prod of the form $A \rightarrow A\alpha$ is called left recursive as the left hand side variable appears as the first symbol on the right-hand.

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